Information on Stressors Affecting Priority Species and Habitats

1. *Alteration of Flows and Other Effects of Water Management*

Hydrograph Alterations. Alteration of the hydrograph can have wide ranging effects on biological resources due to direct and indirect effects on habitat quantity and quality caused by changes in flow. Flows may affect aquatic habitat through changes in depth, velocity, wetted area, water quality, sediment transport, and other factors. Flow related stressors on fish, wildlife, and riparian resources include inadequate flow, flow variability, seasonal flow changes or flow timing, stranding due to flow fluctuation, lack of flushing flows, lack of attraction flows, lack of channel forming flows, saltwater intrusion, and other factors.

Changes in the hydrograph are linked to a number of other stressors and processes in the ecosystem, and actions to address these changes may have benefits for related stressors such as water temperature, hydrological isolation of floodplains, migration barriers, geomorphic process constraints, or lack of riparian regeneration potential.

Restoration actions targeted at hydrograph alterations could include evaluation of water needs for fish or wildlife, or assessment/revision of water management operations. Category III funds cannot be used for direct acquisition of water.

Entrainment Direct mortality to fisheries resources occurs as a result of unscreened diversions, diversions not screened to current standards, inoperable screens, and impingement. The significance of this stressor on a fish population varies depending on the size, location, type, duration and timing of the diversion. Due to the influence of river flows and timing of water diversion on entrainment risk, there is some linkage between entrainment and other water management related stressors.

Restoration actions targeted at reducing entrainment may include new fish screens, screen rehabilitation, screen improvements, or alternatives to screening such as consolidation or relocation of diversions. Alternative diversion methods such as in-gravel wells may also serve to reduce entrainment.

Migration Barriers and Straying. Migration barriers or delays may be caused by physical structures, insufficient flow over shallow areas, inadequate attraction flows, adverse water quality conditions, delayed flooding of marshlands, or other factors. Barriers to movement of migrating fish species are a stressor because they may affect the physical condition (e.g., mechanical injury due to diversions, screens, dams, etc.), physiological condition (e.g., spawning readiness, smolting, etc.), and/or ecological status (e.g., predation risk, run timing, outmigrant survival, etc.) of anadromous fish. Barriers to upstream movement may prevent access to upstream spawning habitat, and delays in upstream migration can increase predation risks and

decrease spawning success. In addition, straying related to barriers can result in loss of adults to the spawning population if they are unable to locate suitable spawning habitat.

Barriers are often associated with other stressors in the system, including water management activities and the associated structures and flow changes, and water quality degradation related to changes in land use.

Restoration actions to address barriers caused by physical structures, water quality constraints, or hydrological conditions could include bypass arrangements such as fish ladders, physical barrier removal, improvements in water quality, or flow changes or augmentation that prevent straying and allow passage.

2. Floodplain and Marshplain Changes

Hydrological Isolation of Floodplain or Marshplain. Hydrological isolation of the floodplain or marshplain occurs when there is a lack of flow over these areas and/or a lack of return flow to the main channel. The lack of flow functionally isolates the floodplain from the main channel, and prevents ecologically beneficial floodplain and river interactions such as gravel recruitment, fine sediment deposition on the floodplain, nutrient input to the river, riparian zone regeneration, woody debris recruitment input, creation of spawning habitat, and other important processes.

Reconnection of the hydrological link between the river and floodplain can be addressed through a variety of physical or hydrological changes, including improved drainage connections between floodplains and rivers, alteration of the hydrograph to facilitate floodplain inundation, or restoration of hydrological links to historic floodplain areas.

Physical Isolation of Floodplain or Marshplain. Physical isolation of the floodplain or marshplain includes habitat fragmentation, loss of seasonal and tidal wetlands due to levee construction, or other land use changes that physically separate the floodplain or marshplain from the main water channels. Physical isolation of these areas results in habitat discontinuities which decrease their suitability for aquatic and terrestrial species. Physical isolation of the floodplain or marshplain is closely linked with hydrological isolation, and related land use stressors on the ecosystem.

Restoration actions associated with floodplain or marshplain habitat could include reconnection of the floodplain or marshplain to the water channel to allow a more natural inundation cycle, using setback levees, flood bypass areas, floodplain easements, or other methods. Other actions could include managed flooding of historic floodplain areas or suitable agricultural lands.

Elimination of Fine Sediment Replenishment. Fine sediment replenishment of floodplain and marshplain areas occurs when these areas are inundated by high flows or tidal action. This process is interrupted by isolation of the floodplain or marshplain, and can result in decreased

food production and diminished nutrient cycling due to a lack of fine sediment deposition in vegetated areas. Restoration actions that address hydrologic or physical isolation of the floodplain or marshplain can also address this stressor.

3. Channel Form Changes

Alteration of Channel Form. Alteration of channel form includes loss of shallow water habitat due to channel reconfiguration, channel deepening, lack of floodplain, degradation of instream habitat conditions, and loss of lotic conditions (free flowing stream conditions). These changes result in reduced suitability of in-channel or stream corridor habitat for fish and wildlife species due to changes in hydraulic conditions, cover, predation risk, and other factors.

Channel form alterations are generally aimed at restoring natural physical processes within the constraints of a managed system. Projects may include streambed alterations to increase channel complexity, substrate changes, restoration of slough or mid-channel island complexes, or other floodplain manipulations.

Prevention of Channel Meander. Channel meander is a natural process that contributes to creation and maintenance of important aquatic and terrestrial habitat features. Preventing channel meander can result in associated stressors such as channel deepening, loss of shallow water habitat and channel complexity, reduced gravel recruitment, riparian encroachment, and bank armoring. Prevention of channel meander is linked to other floodplain stressors, such as isolation of the floodplain, water management activities, changes in the hydrograph, and lack of riparian vegetation.

Actions which restore channel meander and/or associated natural processes may include protection of existing riparian belts or creation of new riparian areas, increasing channel complexity through structural modification, and construction of setback levees.

Isolation or Elimination of Sidechannels and Tributaries. Isolation of sidechannels or tributaries due to structural changes or water management actions can lead to a loss of woody debris recruitment, loss of rearing and spawning habitat, loss of refuge habitat, and decreased food production for fish and wildlife species. This stressor is linked to other floodplain related stressors such as floodplain isolation, prevention of channel meander, land use changes, and alteration of the hydrograph.

Actions which restore processes associated with tributaries and sidechannels could include main channel changes, structural modifications to habitat in existing channels, or reconnection of isolated channels or tributaries.

Reduction of Gravel Recruitment. Reduction of gravel recruitment results in a direct loss of spawning habitat, and the potential for increased gravel armoring that makes gravel beds less

suitable for spawning. This stressor is related to other floodplain processes such as channel meander, and water management actions that affect flood flows and floodplain inundation.

Gravel recruitment actions may include gravel source identification, spawning gravel acquisition, gravel introduction, spawning gravel improvement projects, or measures to increase natural gravel recruitment.

Channel Aggradation Due to Fine Sediments. Accelerated erosion or decreased sediment transport capacity can result in changes in channel form by increasing the deposition of fine sediments in the stream channel. Increased fine sediment loads are often detrimental to salmonid species because they decrease the suitability of spawning gravels, and they are a less productive substrate for growth of aquatic invertebrates and other food organisms.

Fine sediment loads are closely linked to land use practices that influence erosion, watershed management in upstream areas, gravel recruitment, and channel form changes that influence sediment transport capacity. Restoration actions related to fine sediment management could include site-specific or watershed-wide efforts to decrease sediment input, mechanical removal of existing sediment, or increases in sediment transport capacity due to water management changes.

Loss of Existing Riparian Zone or Lack of Regeneration Potential. Loss of the riparian zone can be a stressor on the ecosystem by reducing food supplies for fish and wildlife, eliminating Shaded Riverine Aquatic (SRA) habitat, reducing channel complexity, and eliminating cover and nesting habitat. Since the riparian zones are typically associated with floodplains and river banks, they are linked to other stressors such as floodplain isolation, prevention of channel meander, and water management activities. The restriction of many riparian areas to sections of levee creates a close association between riparian habitat and levee maintenance practices such as riprapping or burning.

Riparian restoration projects could include riparian corridor easements, rehabilitation of riparian areas, riparian protection plans, land use changes, restoration of adjacent land for buffer zones, and foraging and nesting habitat.

4. Water Quality

Increased Contaminants. Increased contaminant loads can be caused by urban runoff, agricultural runoff, mine drainage, refineries, wastewater treatment plants, and other point or non-point pollution sources. They can be a stressor on the ecosystem due to acute or chronic toxicity on aquatic organisms, including fish, and may be particularly deleterious for younger life stages of fish that may have longer exposure and higher sensitivity to toxic compounds.

Increased contaminant loads are related to other stressors in the system, including land use

practices and hydrograph alterations.

Contaminant control actions may include identification of pollutant sources, evaluation of effects, remediation, monitoring, or education in order to identify and reduce impacts on salmonids and other aquatic resources.

Increased Salinity. Increases in salinity are a specific type of water quality stressor on freshwater or estuarine species associated with the North Bay and portions of Suisun Marsh and the Delta. Increased salinity may be due to water management, operation of diversions or structures, runoff, etc. Salinity increases are linked to water management and land use stressors. In the North Bay, salinity is linked to historical land uses.

Actions to decrease salinity in freshwater areas could include revised land use practices, flow alterations, runoff control, or other measures.

Increased Nutrient or Carbon Input. Increased input of nutrients from agricultural runoff, wastewater treatment, and other sources can be an ecosystem stressor, and may be associated with low dissolved oxygen or other water quality stressors. In particular, low dissolved oxygen levels can link this stressor to related migration barriers. Restoration actions which limit the deleterious input of large quantities of nutrients may include agricultural runoff control, wastewater treatment, flow management in critical areas, or other measures.

Increased Mobilization of Contaminants Due to Dredging. Dredging can be a stressor on the ecosystem due to increased turbidity, contaminant mobilization, or associated dredge spoil disposal issues. In some cases, turbidity and contaminant mobilization can result in acute or chronic toxicity problems for aquatic species. Land based dredge spoil disposal may have associated terrestrial habitat impacts on plant and wildlife species.

Dredging related restoration actions may address methods for controlling turbidity effects, preventing mobilization of toxic compounds, facilitating safe dredge spoil disposal, or developing beneficial uses for dredge spoil.

5. Water Temperature

High water temperatures are a stressor on many cold water aquatic species, and may be caused by lack of riparian shade, lower flows, increased water surface area, warm water inflow, or other factors. Warm water temperatures can adversely affect spawning or rearing habitat, especially for salmonids. Since high water temperature can affect multiple life stages of a species, its impact on the egg, fry, and smolt lifestages of salmonids can result in a substantial cumulative mortality effect.

Water temperature is closely correlated to air temperature in many cases, but may be heavily

influenced by the related stressors of hydrograph alteration (particularly below large reservoirs) or lack of riparian shade.

Water temperature related actions not included as part of hydrograph alterations or riparian revegetation may include increased modeling or monitoring work, and evaluation of additional temperature management options.

6. Undesirable Species Interactions

Introduction of New Exotic Species. Introduction of new exotic species can occur from ballast water discharge, inadvertent release of exotic species, or intentional introduction of exotic species for other reasons. Exotic species represent a predatory and competitive threat to native species, and can compromise beneficial uses of native fish, wildlife, and plants. Control of exotic species introductions is closely linked to educational efforts associated with human disturbance of the ecosystem. In addition, an overall improvement in ecosystem health can decrease the system's vulnerability to colonization by exotic species.

Actions which address introduction of exotic species may be regulatory or educational in nature, and may include specific actions aimed at preventing new exotic species introductions.

Elevated Predation and Competition Losses. Predation and competition are natural mortality factors that may have an unnaturally significant effect on native fish populations when they are intensified by introduced species, habitat changes that favor predators or introduced species, or other changes that increase the vulnerability of the prey. Elevated losses of native species may occur due to striped bass predation, other introduced predatory species, competition for nest sites by introduced bird species, competition for food resources by introduced fish or mollusk species, and other factors. This stressor is directly related to introduction of exotic species, and to water management activities or land use actions that may alter habitat conditions in favor of predators or introduced competitors.

Predator or competitor control actions may include control or eradication programs, habitat modifications to decrease unnaturally high predation, or research projects related to exotic species control.

Competition from Introduced Plants. Competition from introduced plant species may include invasive aquatic plants such as Hydrilla, invasive riparian zone plants such as Arundo, or invasive salt marsh plants. These species can outcompete native species that provide a better food supply for native fish and wildlife species, or they can be so prolific that they create problems for other beneficial land and water uses such as agriculture, water supply, or navigation. This stressor is directly related to introduction of new exotic species.

Minimizing deleterious impacts from exotic plant species may involve control efforts,

eradication programs, education programs, or other measures.

7. Adverse Fish and Wildlife Harvest Impacts

Fish and wildlife harvest is a direct mortality factor which can have adverse effects at the population level under certain circumstances. These circumstances may include ocean and freshwater overharvest (particularly in cases of depleted salmon runs), poaching, or inadequate fishing regulations related to size limits or fishing locations. Poaching of migrating adult salmon after they have entered the tributaries can be particularly detrimental, since most of these fish would have successfully spawned and contributed to greater smolt production.

Potential restoration actions may be related to either legal or illegal harvest, and could include research projects, or improved management tools or techniques.

8. Population Management

Population management stressors include migratory pathway changes caused by physical (e.g., water diversion or barriers) or biological (e.g., genetic) factors, and inadequate reproductive capacity due to small or non-existent spawning populations. These stressors can result in reduced production of smolts due to poor spawning success or adverse outmigration conditions. Population management stressors are related to artificial propagation of fish and the associated genetic and management implications, and also to water management activities that may result in migratory pathway changes.

Population management actions could include genetic investigations related to wild stocks; actions to improve monitoring, sampling, or management of stocks; and establishing or supplementing salmon populations.

9. Land Use

Grazing. Grazing is a land use stressor that may be manifested as a loss of riparian habitat, increased erosion, or decreased water quality that can adversely affect beneficial uses of the ecosystem, and impair the suitability of fish and wildlife habitat. Grazing is related to other stressors in the ecosystem, including other land uses and water quality.

Actions addressing problems related to grazing may include land use changes, fencing, erosion control projects, development of easements, water quality control actions, watershed planning and management, or other measures.

Gravel Mining. Gravel mining is a land use stressor that can result in decreased gravel recruitment, increased fine sediment input, decreased quality of spawning and rearing habitat, increased predation due to gravel pits, warmer water temperatures, stream channel instability,

and deleterious changes in channel form. These changes can reduce the suitability of instream physical habitat for many species, and may cause associated water quality problems. Gravel mining is linked to other land use actions, as well as floodplain isolation stressors.

Actions addressing impacts associated with gravel mining could include channel stabilization measures, spawning gravel augmentation, erosion control measures, land use changes, alteration of mining practices, prevention of gravel pit capture by the stream, or other measures.

Urbanization. Urbanization of the watershed may lead to loss of riparian habitat, habitat fragmentation, drainag of wetlands, encroachment into the floodplain, pollutant runoff, and other impacts on the ecosystem. These stressors result in decreased habitat suitability, and can impair other beneficial uses of the system due to changes in water quality or needs for more intensive water management (such as flood control actions). Urbanization is related to other land use stressors, as well as water quality issues and floodplain isolation.

Restoration measures aimed at urbanization impacts may be regulatory, educational, planning oriented, or related to land acquisition.

Forestry and Agricultural Practices. Forestry and agricultural practices in the watershed can be stressors due to conversion of floodplain to agricultural use, land subsidence, increased erosion, loss of habitat complexity, and water quality degradation. This can result in decreased suitability of an area for fish and wildlife habitat, water supply, agriculture, or other beneficial uses. Forestry and agricultural practices are related to other land use stressors, as well as water quality concerns and floodplain isolation.

Restoration actions related to these practices may be site-specific or watershed-wide, and may include planning efforts, educational programs, acquiring easements or buffer zones, or developing technical management practices.

10. Artificial Propagation of Fish

Artificial propagation of fish can be a stressor on the wild population due to genetic changes and related fitness concerns associated with hatchery management, run or stock hybridization, altered timing of runs, effects of smolt releases on wild populations, introduction of pathogens, incidental spring run mortality, increased striped bass populations, and other factors. Artificial propagation activities are related to overall population management stressors.

Restoration actions related to artificial propagation could include evaluation of existing hatchery operations, assessment of new hatchery needs, or studies of hatchery impacts and benefits. Hatchery expansion planning is not included in the 1997 Category III funding cycle.

11. Human Disturbance

Human disturbance of fish and wildlife populations or habitat by anglers, boaters, and other recreational users could include disturbance of nest sites, trampling of salmon redds, and boat wake damage to SRA habitat. The disturbance can lead to habitat degradation and adverse effects on fish or wildlife populations.

Restoration actions addressing other stressors can be made more effective by implementing associated education or other actions to limit human disturbance. The education actions could serve to increase overall public awareness, or may target particular audiences to modify behavior.

12. Wildfi :

Wildfire is a potential stressor on the ecosystem due to the associated loss of habitat, particularly in riparian zones. Ecosystem stress related to fire may be intentional, as in the case using fire for clearing levees, or it can be related to increased frequency of fire in riparian zones near urban areas.

Restoration actions related to fire management may include development of alternatives to use of fire for levee maintenance, and control of fire within riparian corridors (particularly in urban areas).